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OUTLINE OF PLEISTOCENE HISTORY OF MISSISSIPPI VALLEY[1]

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RELATION OF PRESENT STREAM TO PREGLACIAL VALLEYS

The headwater portion of the Mississippi River, above St. Paul, Minnesota, is in a region so thickly covered by glacial deposits that the present streams are entirely independent of the preglacial valleys, and their history begins with the recession of the ice in the last, or Wisconsin, stage of glaciation. The courses of preglacial drainage lines in this region have been only partially traced by means of deep borings. This paper deals, therefore, mainly with the part below St. Paul.

For 15 miles below St. Paul the Mississippi follows the valley of a small tributary of the preglacial river, the course of the main valley being a few miles to the west, passing beneath Lake Minnetonka, and across the lower end of Minnesota Valley, and continuing through Dakota County to the present stream at Pine Bend, 6 miles above Hastings. From Hastings to Clinton, Iowa, the river practically follows the course of the preglacial valley, though it cuts off projecting points from the west bluff at Trempealeau, Wisconsin, and in the north part of Clinton, Iowa (Fig. 1).

At the mouth of the Wapsipinicon River, below Clinton, the Mississippi leaves the preglacial valley, passes into a rock gorge, and flows across rapids to Rock Island. Two courses for the preglacial valley have been suggested, one to the southwest from the lower part of Wapsipinicon Valley to Muscatine, on the present Mississippi, the other to the southeast to Hennepin, on the Illinois Valley. Along both lines the glacial deposits are very thick, and the rock surface much lower than the present streams. The southeastward course seems on the whole more likely to have been

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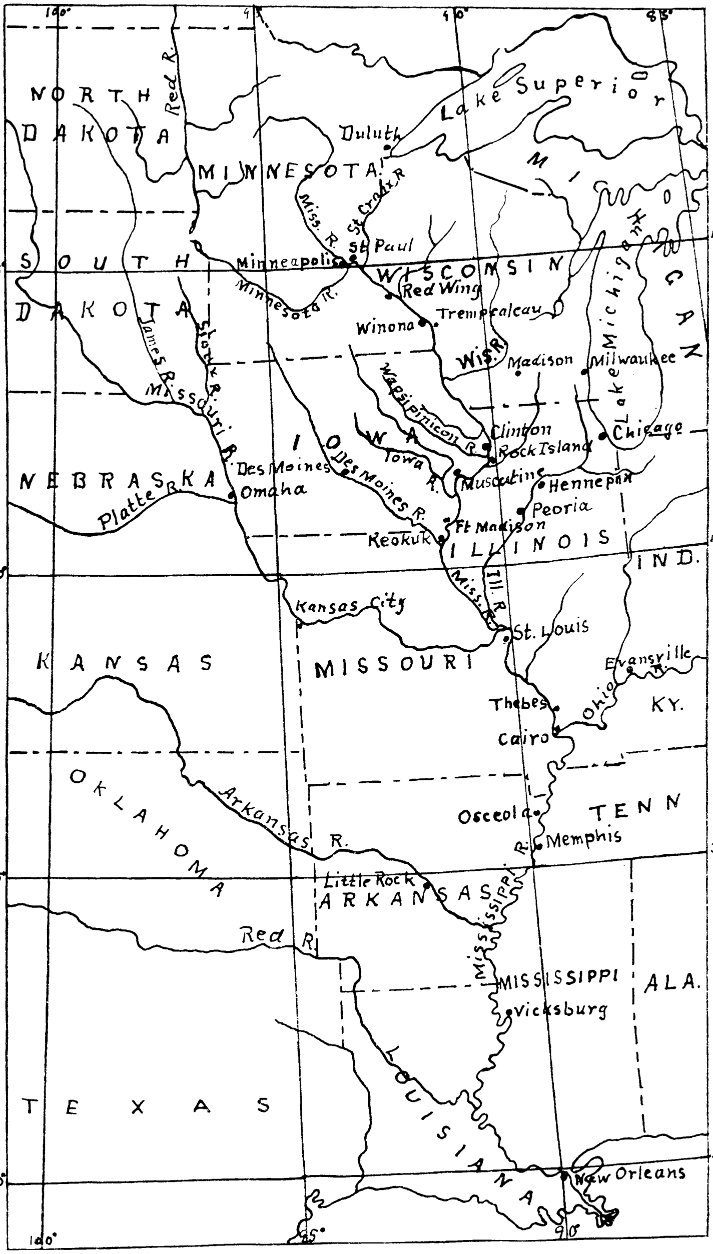

FIG. 1.—Map of Mississippi River

followed by the preglacial Mississippi, for other preglacial valleys converge toward it, one followed by the lower course of the Rock River, reversed, and another by Duck Creek, and its continuation in an abandoned valley to the east of Rock Island. The breadth of the valley leading to the Illinois also appears to be greater than that of the one to the southwest. A different stream from that which opened the upper Mississippi Valley probably developed the valley now utilized by the Mississippi below Muscatine. It is likely to have taken the drainage of much of eastern Iowa and drained the region now tributary to Iowa River, though it does not follow the course of that stream. It may, perhaps, be appropriately called the preglacial Iowa River.

The two drainage lines came together at the mouth of the Illinois River. The western one departed slightly from the present Mississippi in the southeast corner of Iowa, the old course being southwest from Fort Madison to the mouth of the Des Moines River, while the present stream turns southward across the Des Moines rapids to Keokuk, and joins the old valley at Warsaw, Illinois.

The present river follows essentially the course of the preglacial valley from the mouth of the Illinois River to Thebes in southern Illinois, though it has cut off points from the west bluff near Grand Tower, which in high-water stages stand as islands in the valley. The Mississippi turns into a rock gorge at Thebes, and a few miles below comes into the old Ohio Valley, while the old valley runs southwestward, and unites with the Ohio Valley farther down.

RELATION OF PRESENT STREAM BED TO BURIED ROCK FLOOR

The present stream falls from 683 feet A.T. at St. Paul to 566 feet at Clinton, or 117 feet in about 300 miles. This section includes Lake Pepin which holds a level of 664 feet for 25 miles. Aside from this lake the stream has an average fall of about 5 inches per mile. The fall of the buried rock floor is very similar, for it stands 480 to 500 feet A.T. near St. Paul and is below 400 feet in the vicinity of Clinton. The rock floor has more or less inequality because of variations in the scour of the stream, and in the hardness of the bed, so its slope conforms only in a general way with that of the stream which occupied it.

On the line of the old valley leading from Clinton southeastward to the Illinois River at Hennepin the rock floor falls to about 340 feet, as shown by borings at Princeton and Bureau Junction, near Hennepin. The Illinois River at Hennepin is 432 feet A.T. or about 90 feet above the rock floor.

The Illinois River has a fall of only 27 feet in 207 miles from Hennepin to the junction with the Mississippi River, or 1.56 inches per mile. From the mouth of the Illinois River to St. Louis, a distance of 41.5 miles, the Mississippi falls 21 feet, or 6 inches to the mile. The rock floor, as shown by borings and bridge excavations opposite St. Louis, is about 100 feet below the low-water level of the river, or 280 feet A.T. This gives a fall of 60 feet from Hennepin to St. Louis in 248 miles, or about 3 inches per mile.

The distance by the course of the present Mississippi from Clinton to St. Louis is about the same as along the line to Hennepin and down the Illinois, being not far from 300 miles. The fall is about 180 feet, of which 48 feet is over rock rapids in a distance of 24 miles. The remaining 132 feet is at the rate of less than 6 inches per mile. The rock floor in the valley below Muscatine is known to be 100 feet or more below low water. It has been best tested at Fort Madison, and found to be 120 to 135 feet below low water, or 365 to 380 feet A.T. There is thus a fall of nearly 100 feet between Fort Madison and St. Louis in about 200 miles, or a rate very similar to that of the present stream, aside from the rapids.

The fact that these buried valleys have beds 100 to 180 feet below the low-water level of the present streams has led certain geologists to infer that the altitude must have been higher than now when they were excavated. There are, however, certain other conditions that have had influence in causing this difference. One of these conditions is a marked lengthening of the lower course of the Mississippi, or extension of its mouth gulfward, in the long period since the river was flowing on this rock bed. Warren Upham has presented evidence from a study of old maps of the lower course of the Mississippi that the delta has made a marked extension in the past 400 years.[1] The time since glaciation came in to displace the streams from their preglacial beds is likely to be at least 1,000 times, and perhaps 2,000 times, as long as the 400 years involved in the growth noted by Upham. The extension may, therefore, be as great as from the site of Vicksburg, and perhaps from farther up. With this lengthening there would come a corresponding aggradation of the valley causing the stream to flow at a level materially higher than its rock bed. Studies by the present writer near Osceola in the northeast part of Arkansas have shown that the flood plain has been built up about 35 feet by a sediment finer than the underlying sand presumably in Pleistocene time. So the aggradation there appears to have been at least that amount, and it would be fully as great farther up the valley.

Another condition that affects the Mississippi Valley below the mouth of the Missouri River, results from the greater amount of sediment now brought in by that stream and carried down the Mississippi, as compared with that likely to have been carried by it before its watershed became so extensively covered with loess, for loess furnishes the main part of the sediment. With increase of load a stream raises its gradient. The Missouri has a fall of about 300 feet in its lower 300 miles, while the section of the Mississippi which is less heavily loaded with sediment has a fall of only about 150 feet. Below their junction the stream has a slightly higher rate of fall than that of the Mississippi above the junction, it being 7.2 inches per mile from the mouth of the Missouri to the mouth of the Ohio. The effect of this load of sediment is clearly brought out by comparing this section of the Mississippi with the section of the Ohio immediately above its mouth. The rate of fall in the lower 200 miles of the Ohio is only about 3 inches per mile, or less than half that of the Mississippi; yet the Ohio is a smaller stream, and should have a higher gradient were it carrying a similar load. There is a difference of about 70 feet between the fall of the Mississippi and of the Ohio in the 200 miles above their junction, and this may give a measure of the amount of aggradation at the mouth of the Missouri, due to the heavy load of sediment. If to this is added the 35 feet of aggradation that is due to the lengthening of the stream, the full difference between the level of the rock bed and the level of the present river is accounted for. There thus seems no need for postulating disatrophic movement. Farther up the river the rock barriers in the path of the stream, above Keokuk and above Rock Island, contribute in holding the present stream to a high level.

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[1] "Growth of the Mississippi delta," *American Geologist*, Vol. XXX (1902), pp. 103–11.

GLACIATION IN ITS RELATION TO DRAINAGE MODIFICATION

The preglacial Mississippi in its course from near Red Wing in southeastern Minnesota to the lower Illinois valley, and thence to St. Louis and Cairo, appears to have suffered little or no disturbance in the first two stages of glaciation, the Nebraskan, or pre-Kansan, and the Kansan. The Iowa branch of the preglacial Mississippi was more seriously disturbed by these early glaciations. Its valley was so completely filled as far down as Muscatine that its course is known only by borings. It was also completely filled for a few miles in the southeastern corner of Iowa. The filling as far down as the line of Iowa and Missouri is found to embrace the pre-Kansan as well as Kansan drift. In the vicinity of Fort Madison, Iowa, the pre-Kansan drift fills the old valley from the level of the rock floor, 135 feet below the present stream, to a height of about 75 feet above the river. A black soil marks its upper limit. It is overlain by Kansan drift, and this in turn by Illinoian drift, which rests on a soil developed on the Kansan drift. Other records in eastern Iowa, southern Minnesota and western Wisconsin show that valley excavation had reached its lowest limits prior to the earliest glaciation. One of the clearest records is at Washington, Iowa, brought to notice by Calvin.[1] It is in a locality where no drift later than the Kansan is present, and is in the line of a western tributary of the preglacial valley utilized by the Mississippi below Muscatine. The Kansan drift extends to a depth of 115 feet, and rests on a peaty bed containing wood and cones of the black spruce. Below this is the pre-Kansan drift, extending to a depth of 350 feet from the surface, or to about 400 feet above sea-level. This level of the rock floor fits in well with that of 365 feet at Fort Madison. Attention is directed particularly to this evidence that the lowest valley excavation is preglacial, since Trowbridge, of the University of Iowa, has for some years been advocating that a large part of the valley deepening in the upper Mississippi region was accomplished between the pre-Kansan and Kansan stages of glaciation.[1]

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[1] *American Geologist*, Vol. I (1888), p. 28.

The Kansan drift extends beyond the present Mississippi Valley into the western edge of Illinois, but does not appear to reach the Illinois Valley. Its southern limits on the border of the Mississippi Valley are at the city of St. Louis. The amount of filling with glacial deposits is difficult to determine because of the great amount of erosion since they were laid down. It was sufficient in southeastern Iowa to prevent the stream from occupying the old valley again. But below the mouth of the Des Moines it was reoccupied by drainage when the ice of the Kansan stage melted away. The course of post-Kansan drainage from the part of the valley between Muscatine and the Des Moines rapids is more difficult to determine, for it was later occupied by ice in the Illinoian stage of glaciation. Possibly it drained eastward from Muscatine, and together with the upper Mississippi discharged through the lower Illinois Valley. It is probable that nearly all the erosion of the gorge at the Des Moines rapids has taken place since the Illinoian stage. A comparison of the valley to the east from Muscatine with that across the Des Moines rapids indicates that it was opened earlier. Its rock bed has been cut below the level of the present Mississippi, and it is a broader valley with gentler slopes than that across the rapids. The difference may be seen by comparing charts 148 and 149 of the Mississippi River Commission, embracing the part east of Muscatine, with charts 136 and 137, which embrace the rapids. The valley east from Muscatine is also embraced in the Edgington and Milan quadrangles of the U.S. Geological Survey. The opening of this valley eastward from Muscatine may date from the Nebraskan stage and have been occupied by east-flowing drainage down to the Illinoian stage, when it was changed to a west-flowing stream.

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[1] *Proc. Iowa Academy of Science*, Vol. XXI (1915), pp. 208–9; *University of Iowa Studies*, Vol. IX (1921), pp. 123–27.

It seems probable that the Illinoian glaciation was the first to throw the upper Mississippi out of its course through the Illinois Valley. At the culmination of the Illinoian stage of glaciation the Mississippi opened a temporary course across eastern Iowa, just outside the limits of the ice sheet.[1] This connected with the present Mississippi at the head of the gorge across the Des Moines rapids below Fort Madison at a level about 120 feet above the present stream; so nearly all the cutting in rock at these rapids has been done since that time. The Illinoian drift extends a few miles beyond the present course of the Mississippi from Clinton to Fort Madison, but farther north and south its border lies east of the river. With the recession of the Illinoian ice sheet the Mississippi shifted to its present course between Clinton and Fort Madison.

It seems to have been at this time that the course across the rapids above Rock Island was initiated, the ice being still present on the lower land to the east. The channel across these rapids, like that across the Des Moines rapids, has the appearance of being much younger than that between Muscatine and Rock Island.

Goose Lake channel, which branches off from the present Mississippi at the mouth of Maquoketa River and passes southward across Clinton County, Iowa, to the Wapsipinicon Valley, was probably opened in Illinoian time, and may have continued down to Wisconsin time. It seems, however, to have been abandoned before the waters of the glacial lakes began their work of excavation discussed below.

The glacial drainage outside the Illinoian ice sheet in southeastern Iowa carried enough material into the Mississippi Valley below the Des Moines rapids to fill it to a level about 100 feet above the present low-water level of the river. But within a few miles it dropped to a level so nearly the same as that of the filling at the succeeding, Wisconsin, stage of glaciation that it cannot well be differentiated. In each the level of filling is about 60 feet above present low water, and 30 to 40 feet above flood stages.

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[1] Frank Leverett, "The Illinois Glacial Lobe," *U.S. Geol. Surv.*, Monograph XXXVIII (1899), pp. 89–97, Pl. VI.

It is probable that the aggradation at the Illinoian stage was sufficient to enable the river to make use of a low pass across the rock ridge below Thebes, Illinois, and thus join the Ohio more directly than by the old course. The contours of this new course seem to be about the same as in the Des Moines rapids and those above Rock Island, and thus to favor a similar age.

The Iowan glaciation appears to have been too light and transitory, or to have encroached on the Mississippi Valley too little, to produce any permanent deflections of the stream. It may, however, have reached to the valley both from the east and west in the vicinity of Clinton, as indicated by maps and descriptions in Monograph XXXVIII.[1] There are deposits of sandy gravel along some of the tributaries of the Mississippi in southeastern Minnesota and in western Wisconsin that are outside the glacial drainage lines which were connected with the Wisconsin ice sheet, and which are tentatively referred to the Iowan glacial drainage. The material is nearly as fresh as gravel of Wisconsin age, and its preservation from erosion is but little different from that of Wisconsin deposits. It seems, therefore, to be too young to refer to the Illinoian glacial drainage.

The Wisconsin glaciation covered only the headwaters of the Mississippi down to a point a little below St. Paul. But it covered the lower Illinois, and built great moraines to the north and west of Hennepin that have effectually barred the upper Mississippi from returning to its old course into the lower Illinois Valley.

The glacial drainage into the Mississippi from the Wisconsin drift at first had its head on the outer slope of a moraine that crosses the river in the southeast part of the St. Paul quadrangle. The drainage was extended up the valley step by step with the recession of the ice border. At the border of the Wisconsin drift there is an extensive outwash plain, 940 to 960 feet above sea level, or 260 to 280 feet above the Mississippi River. From this outwash plain there was drainage down the course of the Vermillion Valley as well as down the present Mississippi, with a descent of fully 100 feet in about 20 miles. The filling is a fine, sandy gravel, and well records indicate that it was built up from near the level of the present river. At Red Wing the filling is 125 feet above the river, or 790 feet above sea-level. Its slope is more rapid than the fall of the river as far down as the mouth of the Wisconsin River. It is there about 70 feet above the river, or 675 feet A.T. At Bagley, Wisconsin, 12 miles farther down, the filling is only 60 feet above the river, and it maintains a height of 50 to 60 feet above the river from there down to about the mouth of the Ohio River. Just above the Des Moines rapids, in the vicinity of Fort Madison, the Wisconsin filling is exceptionally well preserved at a level 50 to 55 feet above the river.

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[1] *Op. cit.*, pp. 131–153, Pls. VI and XII.

There were accessions from tributaries at several points, the most important being St. Croix, Chippewa, Wisconsin, Rock and Illinois rivers. The Illinois is likely to have made a contribution of sediment to the lower Mississippi larger than that brought down from the upper Mississippi. The Illinois Valley was built up at the Wisconsin drift border, at Peoria, 170 feet above the present stream. In 175 miles from Peoria to Alton, at the head of the American Bottoms on the Mississippi, there is a descent of about 160 feet in the surface of the sandy filling of Wisconsin age, while the present stream falls only about 25 feet in the same distance. Below St. Louis there is sandy filling, which seems referable to the Wisconsin glacial drainage, in small remnants in recesses of the valley and in the mouths of tributary valleys. Filling of this sort is found as far down as the place where the Mississippi turns into the gorge near Thebes. The new topographic map of the Jonesboro quadrangle brings out terraces at the mouths of Dutch Creek and Clear Creek valleys which catch the 380-foot contour. They are 30 feet above the broad flood plain of the river.

DRAINAGE FROM THE GLACIAL LAKES

The Mississippi Valley was the line of discharge to the Gulf of Mexico for several of the great glacial lakes that were developed in front of the receding ice border. Lake Agassiz, with a maximum area as large as that of all the present Great Laurentian lakes, drained into the Mississippi through the Minnesota Valley; Lake Duluth, in the Superior Basin, drained through the St. Croix

Valley, and Lake Chicago, in the Michigan Basin, through the Illinois Valley. At times Lake Chicago carried the drainage of glacial lakes in the Huron and Erie basins. As these lakes were settling basins, their outlets carried very little sediment, and the volume of water being large, they cut deeply into deposits that had been built up by the waters flowing directly from the ice sheet, and developed a low gradient, lower than is consistent with the present Minnesota, St. Croix, and Illinois rivers, or even with the Mississippi River. At the junction of the Minnesota and the Mississippi it cut to a level 30–40 feet below the present streams, and there is now backwater of that depth in the lower end of the Minnesota Valley, caused by the aggrading effect of the Mississippi River. The conditions are similar at the mouth of the St. Croix

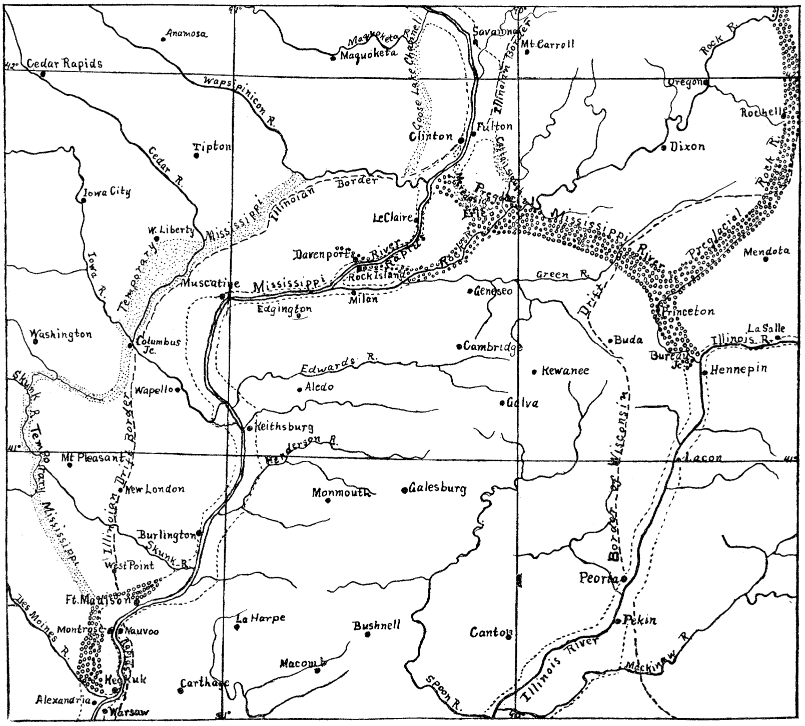

FIG 2.—Map showing shiftings of course of Mississippi River

River, and its lower part, below Stillwater, is known as Lake St. Croix. A few miles farther down is Lake Pepin, where for a length of 25 miles the Mississippi is ponded by a barrier built up from sediment brought in by the Chippewa and Zumbro rivers. The level has thus been raised at least 40 feet at the lower end of the lake. There appears to have been aggradation by the present stream along much of the course from Lake Pepin to the head of the rapids below the mouth of the Wapsipinicon.

The channel across these rapids seems to have been inadequate to carry the great volume of water from the glacial lakes, for part of it flowed southward to Rock River through channels now occupied by Meredosia and Cattail sloughs (Fig. 2), and thence down Rock River Valley to the Mississippi below the rapids. Peat deposits now fill these channels to such height that only the highest floods pass through them, but the beds of the channels are about as low as the low-water level of the present river. The rapids thus seem to have been cut down but little since the waters of the glacial lakes ceased flowing over them. The Des Moines rapids, above Keokuk, took the entire flow of the glacial lake waters. The river at the head of the rapids is 50–60 feet lower than the surface of the Wisconsin deposits of sandy gravel immediately above them. It is probable that much of this lowering is due to the waters of the glacial lakes.

The Illinois Valley was cut to a very low gradient by the waters of Lake Chicago. Under present conditions there is a fall of slightly less than 30 feet in the 220 miles below La Salle. But as the mouth of the Illinois is immediately above the mouth of the Missouri the sediment from that stream may have raised the level of the mouth of the Illinois since the waters of Lake Chicago ceased flowing down the Illinois Valley. The amount of aggradation thus produced is a difficult matter to estimate. Possibly it is as great as that below Lake Pepin, some 30 to 40 feet. Attention was directed above to the influence of the sediment of the Missouri on the gradient of the Mississippi below its mouth.